

NAVAL RESEARCH LABORATORY NAVAL CENTER FOR SPACE TECHNOLOGY

Full-Sky Astrometric Mapping Explorer (FAME)
Ground Software Requirements Specification (SRS)

NCST-SRS-FM002 DRAFT

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Approved By: _____
Dr. Kenneth J. Johnston, Principal Investigator

Date: _____

Approved By: _____
Mark S. Johnson, Program Manager

Date: _____

Approved By: _____
Jeff Johnson, Lead Ground Software Engineer

Date: _____

Approved By: _____
Cognizant NASA Manager

Date: _____

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**4555 Overlook Avenue, S.W.
Washington, D.C. 20375-5000**

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REVISION LETTER	DATE	TITLE OR BRIEF DESCRIPTION	ENTERED BY
—	08 December 2000	1 st Draft for Review	E. Karlin

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1. SCOPE

1.1 Identification.

This Software Requirements Specification (SRS) establishes the requirements for the Ground Software (GSW) Computer Software Configuration Item (CSCI) of the Full-Sky Astrometric Mapping Explorer (FAME) Observatory program, a NASA Medium Class Explorer (MIDEX) mission schedule for launch in July 2004. This Ground SRS is derived from the FAME Detailed Mission Requirements Document (MRD) [NCST-D-FM002].

This document applies to the FAME ground software being developed by the Naval Research Laboratory (NRL). It does not apply to the flight software (also being developed by NRL) or to the instrument software being developed by Lockheed Martin Missiles and Space (LMMS).

1.2 System Overview.

FAME will provide the positions, proper motions, parallaxes, and photometry of nearly all stars as faint as 15th visual magnitude with accuracies of 50 microarcseconds (mas) at 9th visual magnitude and 500 mas at 15th visual magnitude. Stars will be observed with the Sloan Digital Sky Survey g' , r' , i' , and z' filters for photometric magnitudes. This is accomplished by a scanning survey instrument evolved from *Hipparcos* with a mission life of 2.5 years and an extended mission to 5 years. For more information about the FAME science objectives, refer to NCST-D-FM001, FAME Science Requirements Document.

The FAME Ground Software CSCI supports testing of the flight software, integration and test (I&T) of the spacecraft and its components prior to launch, and operations for the observatory after launch. The FAME Ground Software CSCI consists of all the software required to support the applications listed in Table 1-1. Each of these applications utilizes the OS/COMET ground software toolkit as the core infrastructure for sending commands and processing telemetry. The application software built on top of the OS/COMET toolkit provides the mission-specific software for each of these systems. From a software viewpoint, these applications perform many of the same functions, and therefore, the ground software is managed as a single CSCI.

Table 1-1. Ground Software Applications

FAME Application	Purpose
Software Only Test Bed (SOTB)	Flight and ground software development without flight hardware or test bed hardware.
Software Test Bed (STB)	Integrated Spacecraft Controller (ISC) software validation test bed.
Controller Test Bed (CTB)]	Component level I&T of the ISC.
Electrical Aerospace Ground Equipment (EAGE)	System level I&T of the FAME spacecraft.
Electrical Launch Support Equipment (ELSE)	System level test of the FAME observatory and charging of batteries prior to launch.
Satellite Simulator (SATSIM)	FAME spacecraft simulator for flight software verification, interface verification and operations training.
Mission Operations Center (MOC)	Operation of the FAME spacecraft.
Science Operations Center (SOC)	Operation of the FAME instrument.

1.3 Document Overview.

This document details the software requirements for the FAME Ground Software. It is organized as follows:

Section 1, *Scope*: The purpose and contents of this document, and an overview of the FAME program.

Section 2, *Referenced Documents*: A list of documents referenced in or required for use with this document.

Section 3, *Requirements*: Specifies the software requirements for the FAME Ground Software.

Section 4, *Qualification Provisions*: Details the requirement verification methods.

Section 5, *Requirements Traceability*: Requirements Traceability Matrices for the FAME Ground Software.

Section 6, *Notes*: Includes a list of acronyms and abbreviations used in this document.

2. APPLICABLE DOCUMENTS

This section lists documents that either are referenced in this Software Requirements Specification or provide additional information applicable to the understanding of this document.

2.1 Government Documents.

2.1.1 NRL Documents.

The NRL documents listed in Table 2-1 are FAME project specific.

Table 2-1. NRL Documents

Document Number	Document Title
NCST-D-FM001	Science Requirements Document for the Full-sky Astrometric Mapping Explorer (FAME)
NCST-D-FM002	Mission Requirements Document for the Full-sky Astrometric Mapping Explorer (FAME)
NCST-D-FM003	Project Management Plan for the for the Full-sky Astrometric Mapping Explorer (FAME)
NCST-D-FM004	Systems Engineering Management Plan (SEMP) for the Full-sky Astrometric Mapping Explorer (FAME)
NCST-SDP-FM002	FAME Ground Software Management Plan (SMP)
NCST-ICD-FM003	Space to Ground ICD for the Full-sky Astrometric Mapping Explorer (FAME)

2.1.2 Military and International Standards.

The FAME Ground Software CSCI uses the military standards (MIL-STD) and international standards listed in Table 2-2

Table 2-2. Military/International Standards

Document Number	Document Title
MIL-STD-498	Software Development and Documentation, 5 December 1994
ISO/IEC 12207	Information Technology – Software Life Cycle Processes, August 1995
ISO/IEC 9899	ANSI C Standard Programming Language

2.2 Non-Government Documents.

2.2.1 Commercial Documents.

The commercial documents listed in Table 2-3 provide additional information on commercial off-the-shelf (COTS) software:

Table 2-3. Commercial Documents

Vendor	Document Title
Wind River Systems	VxWorks Programmer's Guide
Wind River Systems	VxWorks Reference Manual
Wind River System	VxWorks User's Manual
Rational	ClearCase/ClearQuest Administrator's Manual
Rational	ClearCase/ClearQuest User's Manual

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3. REQUIREMENTS

Each requirement group has an identifier associated with it that shall be used throughout the software development process to track the requirements. The convention used for these requirement identifiers is a two-letter acronym describing the software area of the requirement group followed by a four-number “tag” indicating the specific requirement. The two-letter acronyms for software functional areas are given in Table 3-1. The two-letter acronym NF is used for non-functional requirements.

3.1 Required States and Modes.

The FAME Ground Software operates in two distinct states identified as the off-line state and the on-line state. The off-line state allows activities such as software configuration (e.g. building telemetry processing databases) and analysis of recorded information. The on-line state allows activities such as real-time telemetry acquisition, processing, and display as well as real-time device commanding.

Within each of the two operating states, the mode of the FAME Ground Software is determined by the application it is currently supporting. The particular applications supported are described in Table 1-1.

3.2 Capability Requirements.

The Ground Software capability requirements are partitioned into eight (8) major functional areas, which are shown in Table 3-1.

Table 3-1. Ground Software Functional Areas

Software Function Acronym	Software Function Name
TL	Top Level
TM	Telemetry
TC	Telecommand
MP	Memory Processing
AP	Archive and Playback
CS	Control System Core Services
GE	Ground Equipment
MU	Mission Unique

3.2.1 Top Level Requirements (TL).

The top-level requirements are merely a temporary placeholder for system level requirements from the MRD and other identified requirements that drive Ground Software development.

SRS Group	Number	Requirement
TL	1010	The ground software shall provide command, control, and telemetry support for all FAME integration and test configurations (SOTB, STB, Flight Controller EAGE, Spacecraft EAGE, ELSE, SATSIM).
TL	1020	The ground software shall provide command, control, and telemetry support for all FAME operational configurations (MOC, SOC).
TL	1030	The ground software shall provide compatibility with NRL's Blossom Point (BP) ground station system architecture.
TL	1040	The ground software shall support a dedicated 11.3 m limited motion antenna system at BP.
TL	1050	The ground software shall provide automated control of ground configurations via an extendible scripting language.
TL	1060	The ground software shall support telemetry acquisition and processing for a continuous CCSDS packetized data stream at the FAME data rates.
TL	1070	The ground software shall forward science data packets and instrument SOH packets to the SOC in realtime.
TL	1080	The ground software shall support monitoring of the on-orbit FAME observatory, including systems status analysis, limit checking, out-of-limits reporting and trending analysis.
TL	1090	The ground software shall provide telemetry archive and playback for both science data and SOH data.
TL	1100	The ground software shall support command uplink and verification per CCSDS COP-1 protocols.

SRS Group	Number	Requirement
TL	1110	The ground software shall support three command modes: real-time, ground preplanned, and onboard scheduling based on uplinked command loads.
TL	1120	The ground software shall support verification of command execution, analysis of results, investigation of anomalies, and response to off-nominal situations.
TL	1130	The ground software shall support initiation of safing measures whenever it is determined that a critical event seriously jeopardizes the mission if it were to continue to operate beyond defined and acceptable operating limits.
TL	1140	The ground software shall support calculation of S/C velocity knowledge, range, and range rate data to 1 cm/sec.

3.2.2 Telemetry Requirements (TM).

The telemetry requirements are listed below.

SRS Group	Number	Requirement
TM	2010	The ground software shall support CCSDS downlink decoding and processing at the FAME telemetry rates.
TM	2020	The ground software shall provide packetized and stream decommutation.
TM	2030	The ground software shall provide limit checking and alarm detection.
TM	2040	The ground software shall provide time tagging support of incoming telemetry.
TM	2050	The ground software shall provide engineering unit and discrete conversion.
TM	2060	The ground software shall provide raw and engineering converted displays.
TM	2070	The ground software shall support derived telemetry processing.
TM	2080	The ground software shall provide telemetry to application software (subscribe/unsubscribe).

3.2.3 Telecommand Requirements (TC).

The telecommand requirements are listed below.

SRS Group	Number	Requirement
TC	3010	The ground software shall support CCSDS uplink processing and encoding at the FAME commanding rates.
TC	3020	The ground software shall support CCSDS (COP-1) command uplink verification.
TC	3030	The ground software shall support command formatting.
TC	3040	The ground software shall support command release time.
TC	3050	The ground software shall support blocks of commands.
TC	3060	The ground software shall support restricted/locked commands (requiring special authorization).
TC	3070	The ground software shall provide for user defined command verification (based on vehicle telemetry).
TC	3080	The ground software shall provide the ability to inhibit command verification.
TC	3090	The ground software shall provide for error/retry processing.
TC	3100	The ground software shall provide a command history.

3.2.4 Memory Processing Requirements (MP).

The memory processing requirements are listed below.

SRS Group	Number	Requirement
MP	4010	The ground software shall provide for flight memory/table loading, dumping and verification.
MP	4020	The ground software shall provide for merging of multiple copies of memories.
MP	4030	The ground software shall provide notification of download status (begin/in progress/complete).
MP	4040	The ground software shall provide off-line decommutation of recorded telemetry.
MP	4050	The ground software shall provide comparison of command loads versus memory dumps.
MP	4060	The ground software shall provide results of the memory comparison to the online system for subsequent loads.
MP	4070	The ground software shall provide for flight memory/table loading, dumping and verification.
MP	4080	The ground software shall provide for merging of multiple copies of memories.

3.2.5 Archive and Playback Requirements (AP).

The archive and playback requirements are listed below.

SRS Group	Number	Requirement
AP	5010	The ground software shall record/playback all telemetry and commands with time tags.
AP	5020	The ground software shall record and retrieve all alarms, alerts, and operator interaction with time tags.
AP	5030	The ground software shall provide the ability to inhibit recording.
AP	5040	The ground software shall provide tools to analyze and generate reports/graphs from recorded data.
AP	5050	The ground software shall provide tools to analyze and generate reports/graphs long-term archived data.
AP	5060	The ground software shall support playback concurrent with active data collections.
AP	5070	The ground software shall provide playback control (start, stop, pause, resume, rewind, start time, stop time, speed).
AP	5080	The ground software shall provide searchable logging of all processing errors and warnings.
AP	5090	The ground software shall provide tools to compress recording files for long-term storage.
AP	5100	The ground software shall record/playback all telemetry and commands with time tags.

3.2.6 Control System Core Services Requirements (CS).

The control system core services requirements are listed below.

SRS Group	Number	Requirement
CS	8010	The ground software shall provide operator messages (pop-up/scrolling).
CS	8020	The ground software shall provide color-coded alarms/alerts/info messages to the operator.
CS	8030	The ground software shall provide alarm/alert/info message filtering.
CS	8040	The ground software shall provide alphanumeric and graphical displays.
CS	8050	The ground software shall provide telemetry/commanding reports and trending.
CS	8060	The ground software shall support printing of alphanumeric and graphical displays and reports.
CS	8070	The ground software shall provide health and status telemetry displays via an Internet browser interface.
CS	8080	The ground software shall provide periodic on line statistics for all processing.
CS	8090	The ground software shall support processing on a LAN or WAN using various processing nodes.
CS	8100	The ground software shall support a heterogeneous network of nodes for off-line analysis.
CS	8120	The ground software shall automatically verify and archive all formal test results.

3.2.7 Ground Equipment Requirements (GE).

The ground equipment requirements relate to the control and monitoring of the hardware devices listed in Table 3-2.

Table 3-2. Ground Equipment Hardware

Vendor	Description	Part Number
Silver Engineering, Inc.	Command Encoder Unit (CEU)	SEI CM-xxxxx-x
AVTEC	Telemetry Decoder (Frame Sync/Convolutional//R-S)	VM-6130
AVTEC	Telemetry Simulator	VM-6140
Datum	VME Time Code Translator	bc336VME
SBS Technology	Dual Channel 1553	SBS ABI-V6-2
Silver Engineering, Inc.	Bus Protection Unit	SEI CM-xxxxx-x
National Instruments	GPB/E-NET Converter	776631-021
Hewlett Packard	System Power Supply	HP6032A
Hewlett Packard	Solar Array Simulator	HPE4350B
Kepco	Bi-Polar Power Supply (battery simulator)	BOP 36-12M

Each FAME Ground Software application listed in Table 1-1 supports a specific ground equipment configuration. The ground software must support the control and monitoring of the subset of hardware devices used for each configuration. Refer to the appropriate engineering drawings to determine the subset of hardware devices within each configuration.

SRS Group	Number	Requirement
GE	6010	The ground software shall format and transmit control commands to all ground equipment according to the specifications in the interface document for each particular hardware device.
GE	6020	The ground software shall collect and process status telemetry from all ground equipment according to the specifications in the interface document for each particular hardware device.

3.2.8 Mission Unique Requirements (MU).

The mission unique requirements are listed below. The mission unique requirements include three sub-functional areas: simulation, test support, and operations support.

The simulation sub-functional area provides for the simulation of spacecraft components using real-time modeling to verify operability of FAME flight hardware and software. The simulated spacecraft component outputs will be determined by orbit and attitude models, electrical power subsystem models, thermal control system models, reaction control subsystem models, external commands, and sensor simulation input.

The test support sub-functional area provides utilities for automated testing of the flight software, individual boxes, subsystems, and the integrated spacecraft. The automated tests will implement the test descriptions documented in TDB.

The operations support sub-functional area provides utilities for on-orbit mission operations.

SRS Group	Number	Requirement
MU	7010	The ground software shall provide test data generation and validation tools.
MU	7020	The ground software shall provide scripts and utilities to automate all formal tests.
MU	7030	The ground software shall provide software required to set and maintain satellite time.
MU	7040	The ground software shall provide software required to time assign telemetry to within 1ms UTC.

3.3 External Interface Requirements.

The external interface requirements are listed below.

SRS Group	Number	Requirement
NF	9010	The ground software shall access the FAME C&T databases to generate run-time products.
NF	9020	The ground software shall accept CCSDS Virtual Channel Data Units containing science data and engineering data from the ground support equipment (GSE).
NF	9030	The ground software shall send CCSDS command transmission frames to the ground support equipment (GSE).
NF	9040	The ground software shall store science data in the TDB format.

3.4 Internal Interface Requirements.

The internal interface requirements are listed below.

SRS Group	Number	Requirement
NF	9050	The ground software shall utilize the COMET software bus for interprocess communication within the Sun Workstation environment.
NF	9060	The ground software shall utilize sockets for interprocess communication when communicating between the Sun Workstation environment and the VME chassis environment.
NF	9070	The ground software shall utilize CCSDS application packets for the underlying format of interprocess communication messages.

3.5 Internal Data Requirements.

The internal data requirements are listed below.

SRS Group	Number	Requirement
NF	9080	The ground software shall utilize the COMET Mfile data format within the Sun Workstation environment.
NF	9090	The ground software shall utilize the COMET Universal Memory Image (UMI) file format for memory load and memory dumps.

3.6 Adaptation Requirements.

The adaptation requirements are TBD.

3.7 Safety Requirements.

The safety requirements are TBD.

3.8 Security and Privacy Requirements.

There are no security and privacy requirements applied to the ground software.

3.9 CSCI Environment Requirements.

The CSCI environment requirements are TBD.

3.10 Computer Resource Requirements.

The computer resource requirements are identified in the following four subsections.

3.10.1 Computer Hardware Requirements.

The computer hardware requirements are listed below.

SRS Group	Number	Requirement
NF	9100	Portions of the ground software shall execute on Sun Workstations with TBD MB RAM and a TBD GB hard drive.
NF	9110	Portions of the ground software shall execute on VME chassis based front-end processors with TBD characteristics.

3.10.2 Computer Hardware Resource Utilization Requirements.

The computer hardware resource utilization requirements are TBD.

3.10.3 Computer Software Requirements.

The computer software requirements are listed below.

SRS Group	Number	Requirement
NF	9120	The ground software shall utilize the VxWorks operating system for software running on the VME chassis based front-end processors.
NF	9130	The ground software shall utilize the Solaris 7 operating system for software running on Sun Workstations.
NF	9140	The ground software shall utilize the COMET spacecraft control software toolkit for command and telemetry applications running on Sun Workstations.

3.10.4 Computer Communications Requirements.

The computer communications requirements are TBD.

3.11 Software Quality Factors.

The software quality factors are listed below.

SRS Group	Number	Requirement
NF	9150	The ground software shall be maintainable.
NF	9160	The ground software shall be testable.
NF	9170	The ground software shall be extensible.
NF	9180	The ground software shall be consistent.

3.12 Design and Implementation Constraints.

The design and implementation constraints imposed on the ground software are as follows.

SRS Group	Number	Requirement
NF	9190	The ground software shall utilize the "C" programming language for all newly developed application software.
NF	9200	The ground software shall utilize one of the following scripting languages for all newly developed application scripts: csh, sh, tcl, or perl.
NF	9210	The ground software shall follow the FAME CM Plan using a COTS CM tool.

3.13 Personnel-related Requirements.

The personnel-related requirements are TBD.

3.14 Training-related Requirements.

The training-related requirements are TBD.

3.15 Logistics-related Requirements.

The logistics-related requirements are TBD.

3.16 Other Requirements.

There are no other requirements applied to the ground software.

3.17 Packaging Requirements.

The packaging requirements are TBD.

3.18 Precedence and Criticality of Requirements.

The precedence and criticality of requirements are TBD.

4. QUALIFICATION PROVISIONS

This section maps FAME Ground Software Requirements to qualification methods that are also known as verification methods. Table 4-1 shows how each of the FAME Ground Software Requirements will be verified. The requirements will be verified by one of the following four methods: Test, Analysis, Demonstration, or Inspection.

Verification by Test (**T**) is a means of verification that employs technical means, including (but not limited to) the evaluation of function operation by use of special equipment or instrumentation, simulation techniques, and the application of established principles and procedures to determine compliance with requirements.

Verification by Analysis (**A**) is a means of verification taking the form of the processing and accumulated results and conclusions, intended to provide proof that verification of a requirement(s) has been accomplished. The analytical results may be based on engineering study, compilation or interpretation of existing information, similarity to previously verified requirements, or derived from lower level examinations, tests, demonstrations, or analyses.

Verification by Demonstration (**D**) is a means of verification in which only readily available observable functional operations are used to determine compliance with requirements.

Verification by Inspection (**I**): is a means of verification consisting of investigation, without the use of special appliances or procedures, to determine compliance with requirements.

Table 4-1. Requirement Verification Methods

SRS Group	Number	Title	T	A	D	I	N/A

5. REQUIREMENTS TRACEABILITY

This section will trace the FAME Ground Software Requirements to the FAME Mission Requirements Document (MRD), where applicable. Ground Software Requirements that are derived requirements are also traced.

5.1 Traceability Matrix: Mission Requirements Document (MRD) to Ground Software.

5.2 Traceability Matrix: Ground Software to Mission Requirements Document (MRD).

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6. NOTES

6.1 List of Acronyms.

API	Application Program Interface
C&T	Command and Telemetry
COTS	Commercial Off-The-Shelf
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
EAGE	Electrical Aerospace Ground Equipment
ELSE	Electrical Launch Support Equipment
FAME	Full-sky Astrometric Mapping Explorer
GSW	Ground Software
FWL	Forward Link
ICD	Interface Control Document
ISC	Integrated Spacecraft Controller
LMMS	Lockheed Martin Missiles and Space
MRD	Mission Requirements Document
NASA	National Aeronautics and Space Administration
NCST	Naval Center for Space Technology
NDI	Non-Developmental Item
NRL	Naval Research Laboratory
OS/COMET	Open Systems/Common Environment Test
RTL	Return Link
SCL	Spacecraft Command Language
SDD	Software Design Document
SEMP	Systems Engineering Management Plan
SMP	Software Management Plan
SOTB	Software Only Test Bed
SRR	System Requirements Review
SRS	Software Requirements Specification
STB	Software Test Bed
STD	Software Test Description
STP	Software Test Plan
STR	Software Test Report
SUM	Software User Manual
SVD	Software Version Description